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# EVIDENCES OF RECENT ELEVATION OF THE SOUTHERN COAST OF BAFFIN LAND.<sup>1</sup>

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*Introduction.*—This paper is the outgrowth of the opportunity afforded for studying the lands at several places in and north of Hudson Strait, during the past summer, while a member of the Cornell Greenland party, with the sixth Peary expedition. Four stops were made in all along the coast of Baffin Land, three going up, as follows: Big Island; the mainland, just north of the island; and Icy Cove on Meta Incognita. The fourth landing was at Niantilik Harbor in Cumberland Sound on the return homeward.

<sup>1</sup> The writer is greatly indebted to various members of the expedition for valuable suggestions and help, especially Mr. Bonsteel, who stopped with him on the island; but, whatever value this paper may contain is largely due to Professor R. S. Tarr, who kindly directed the work throughout. To all the writer wishes to express his thanks and add his most grateful acknowledgments.

## BIG ISLAND.

*Location, description and topography.*—The location of the island is immediately off the southern coast of Baffin Land, in Hudson Strait, and separated from the mainland by a narrow channel of water, ten to twenty miles wide, known as White Strait—in north latitude  $62^{\circ} 30'$  to  $63^{\circ}$  and west longitude  $70^{\circ}$  to  $71^{\circ} 10'$ . It is some twenty-five to thirty miles in the direction of its longest axis, which is northwest and southeast, and has an average width of from five to ten miles. The coast is a steep and irregular one, being much cut up by fiords and embayments. The highest land reached on the island was 470<sup>1</sup> feet above sea level. Its surface has been deeply incised by interlocking fiordic<sup>2</sup> valleys, which are quite broad at their tops, with the ridges or divides between, of a typical moutonn  d form. These, of course, are on their tops narrow in proportion as the valleys are wide. The rise and fall of the tides is about thirty feet. The topography shows marked signs of glaciation, though, in places, it has been greatly modified by weathering, which has been chiefly of the mechanical kind and on a large and rapid scale. Notwithstanding the great amount of mechanical weathering, due almost entirely to frost action, chemical disintegration is distinctly noticeable. Many sections which have been but recently uncovered by ice are rough and angular, with nearly every trace of glaciated form obliterated.

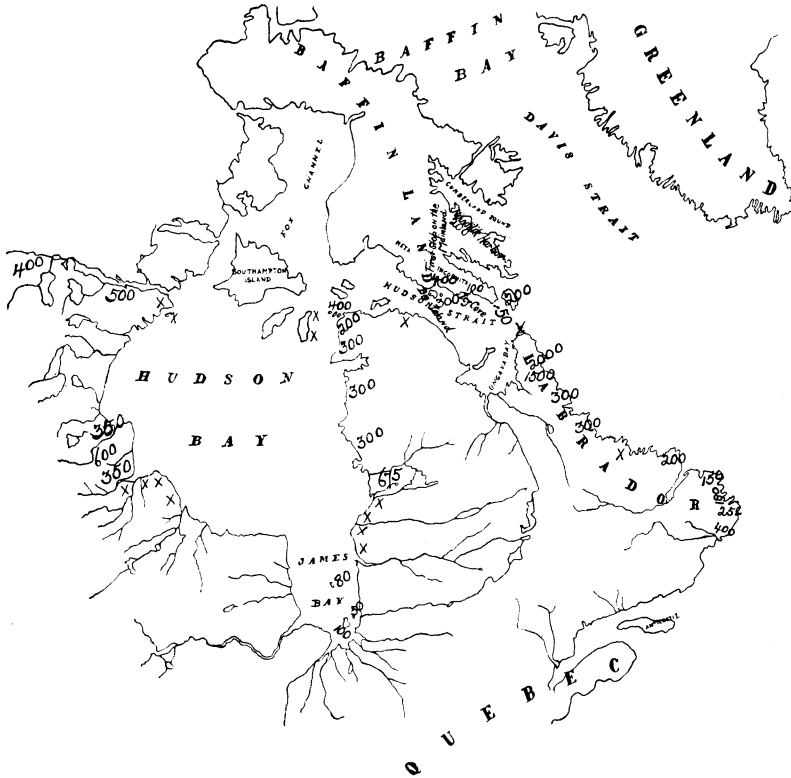
*Kind of rock.*—The rocks consist of regularly banded hornblende-biotite gneiss, complexly folded and gray in color, the intensity of which varies according to the amounts of the dark minerals present. The gneisses are intersected by numerous pegmatite veins composed of the same minerals.

*Proofs of elevation in raised beaches.*—In nearly every valley studied, one of its most prominent and striking characteristics was the occurrence of shore lines in the form of distinct beaches. Sometimes a full and complete series of half dozen or more of these would be found in a single valley at different elevations,

<sup>1</sup> All altitudes were measured with an aneroid barometer.

<sup>2</sup> The term "*fiordic*" is here used in the sense of "fiord-like."

while in others only one or two would occur. These were, in most cases, well developed, level topped, and composed of well-rounded, water-worn material, four-fifths of which was distinctly



SKETCH MAP OF THE HUDSON BAY REGION.  
BAFFIN LAND AND LABRADOR.

FIGURES REPRESENT THE LOCATION OF RAISED BEACHES WITH MEASURED ELEVATIONS ABOVE PRESENT SEA-LEVEL.  
X. LOCALITIES IN WHICH RAISED BEACHES HAVE BEEN NOTED WITHOUT ELEVATIONS ABOVE SEA-LEVEL.

THOMAS L. WATSON  
1886

derived from the local gneisses. However, they contained as well quite a noticeable quantity of foreign material, *e. g.*, shale, limestone, quartzite, etc. This material was variable in size in the lower beaches, and also in several of the higher, though noticeably uniform and coarse for the higher ones. With reference to the size of the materials composing these beaches, several different types

were represented, from the true sand and gravel, on the one hand, to the typical boulder beach on the other, with all gradations between these two extremes. Except for the materials being covered with lichens, these are as fresh and perfect in every respect as though they had been formed but yesterday. In the majority of cases the beaches extended entirely across the valleys from side to side, although it was not uncommon to find them thinning out at one end, and only reaching from one-half to two-thirds the entire distance. They were variable in dimensions, in width from 10 to 50 yards, and in length from 60 to 110 yards. Their length depended upon the width of the valleys in which they were formed. In elevation they ranged from 270 feet above, down to sea level; and, so far as studied, could be correlated throughout.

The best developed and most uniform and regular series of beaches found were in a valley<sup>1</sup> which began at the north end of Ashe Inlet, with a direction<sup>2</sup> S. 13°.5 W. The divide in this valley is located nearer the southwest end, and about 1000 yards from its northern terminus in Ashe Inlet. Unlike most of the other divides on the island, which are composed of loose material, either glacial or beach deposits, this one is formed of the gneissic rock, in situ, and is exposed for the entire width of the valley with an elevation of 185 feet above sea level. The first beach is built immediately against this rocky divide at an elevation of 175 feet above sea, with an average width of some forty feet. The second beach is 165 yards beyond the first one, northward, at 125 feet above sea, and is the best developed one of the series in this valley, with a width of some one hundred feet. Between these two slight fragmentary ones are scat-

<sup>1</sup>It was on the south side of this valley, only a short distance from Ashe Inlet, that the Hudson Bay Company established their scientific station, or Observatory No. 3, in 1884; and it was in their house that we camped during our stay on the island.

<sup>2</sup>Through the kindness of Mr. G. R. Putnam, of the U. S. Coast and Geodetic Survey, the writer has been enabled to give all bearings in terms of true North and South readings. Mr. Putnam states that the compass needle is rather unstable in these regions; also, there may be daily changes of several degrees, and the effect of local attraction is likely to be great.

# **BIG ISLAND** **PROFILE FROM SEA LEVEL TO TOP OF UPPERMOST BEACH** 1896.

PROFILES SHOW THE HEIGHT OF BEACHES ABOVE SEA LEVEL.  
 BEACH RIDGES SHOWN BY INVERTED V's.  
 HEIGHT ABOVE SEA LEVEL INDICATED IN FEET.

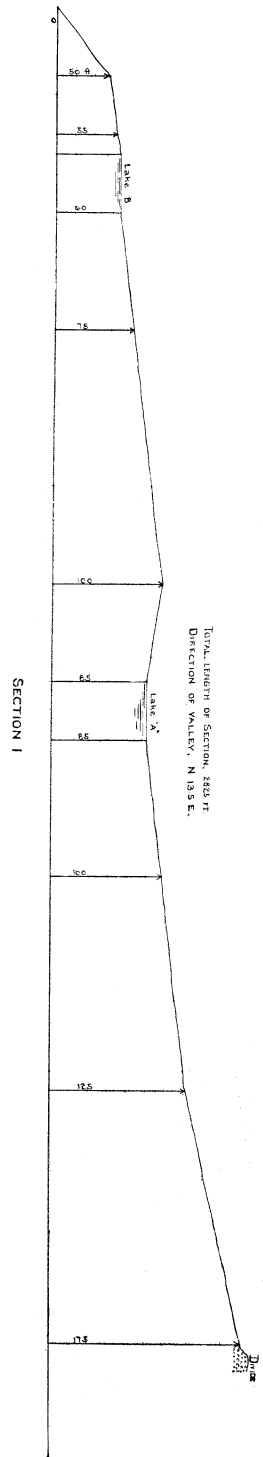
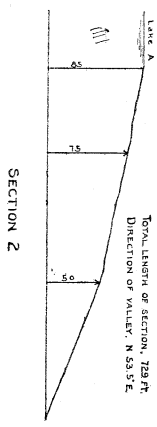


FIGURE 1

tered, within a few feet of each other. The third and fourth beaches are found at the same elevation, 100 feet, and about equally distant from the opposite sides of a rock-basin lake which has been formed in the intersection of this, with a second valley, whose direction is N.  $53^{\circ}.5$  E. The fifth beach is found at an elevation of 75 feet, and at a distance of about 165 yards from the fourth one, with an average width of some 60 feet. This is the last well-developed beach in this valley, though there are two fragmentary ones found at the respective elevations of 55 and 50 feet above sea. These are located on the north side of and at a short distance from a second small lake, whose surface is 60 feet above sea and 75 yards from the fifth beach.

In the southwest half of the valley, which has been mentioned above as crossing the one just described, are found two well-developed beaches at the respective elevations of 50 and 75 feet, which are correlated with the two corresponding beaches in the above series.

In the next valley immediately beyond, eastward, and approximately parallel to the one trending S.  $13^{\circ}.5$  W., is found the largest, and by far the best-developed, beach seen on the island. It is distinctly a sand and gravel beach, 40 feet high, with its crest 175 feet above sea, and about 120 feet wide by 330 long. It serves as the divide in its valley, and is the correlative of the 175-foot beach in the first series.

*Proofs of elevation in differential weathering and unlike surface conditions.*—The fact of recent elevation of this island does not rest alone upon the evidence of raised beaches, though this, to be sure, is entirely satisfactory in itself. It is confirmed by other geological evidence of a very strong nature. Apparently there exist on this island two sharp and well-defined zones, whose surface conditions, in nearly every respect, are very markedly different from each other. The first zone, which begins at present sea-level, and has its upper limit about 300 feet above sea, includes all the land below that level. This zone includes the hilltops for a distance of from two and one-half to three miles back from the sea, and the bottoms of all the major valleys observed on

the island. Excepting the valley bottoms, which are filled with quantities of unusually large and well-rounded boulders, this belt has been stripped of its loose material in the form of glacial drift ; consequently the bare and naked rock is exposed on the hilltops. The attack of the agencies of weathering upon the surface of this area has been in progress, more or less, ever since the rock was exposed, but the effect is far less than that over the areas above an elevation of 300 feet. This would naturally follow, since it will be shown that up to this elevation the waters have but recently subsided or fallen. By far the larger quantity of loose materials which are scattered here and there over this zonal surface is rounded and waterworn. Mechanical weathering has in places shown its effect, and angular masses are seen scattered about somewhat sparingly, in the form of small talus deposits. This zone will embrace at least three-fourths of the total land area of that part of the island visited.

The second zone has its lowest level and beginning at the 300-foot elevation and includes all the surface above, including an area which is not continuous, being merely the tops and sides of the hills for two-thirds of their distance downward. In this zone the bedrock is seldom seen, but is covered to an unknown depth with very large and loose angular blocks ; in a few places, however, the bedrock outcrops at the surface in the shape of small knolls of somewhat decayed rocks. These angular rocks are clearly derived from the local gneisses, presumably largely, if not entirely, by frost action. In some cases they are weathered to a thoroughly crumbled condition. The scarcity of glacial boulders in this angular mass was very striking, yet a few, which proved in each instance to be of foreign source were seen.

Along the sides, at an elevation of from 50-75 feet above the valley bottom, which was 220 feet above the sea, were noted patches of pebbles and boulders, mostly the latter. These were deposited in small channel ways which had been carved by temporary streams flowing down the valley sides. Fully a half dozen of these were seen at different places on the same hill-



side and at the same elevation. A short distance above this the loose angular material commenced to cover the surface. These conditions would seem to indicate that the waters of the sea had their level near this elevation, when these deposits were formed in what then were the mouths of the present channel ways. Such loose and angular material as may have extended below that line was subjected to sea action. It was ground up and distributed in the usual way over the sea bottom. It might be of interest to mention that in this valley was found a series of beaches, four in number, which were distinct and perfect pebble beaches, deposited on a shelf rising some 50 feet above the valley floor.

For the sake of a brief comparison let us note the salient features of the two zones. The first zone is characterized by a seaward strip of land, some two and one-half to three miles wide, reaching an elevation of some 300 feet, with deeply incised valleys (a feature common to both areas) and occupied by raised beaches. This zone skirts the higher interior land area, which has been termed the second zone. Furthermore, this area has its rock bare and more or less polished by glacial action with but little material strewn over its surface, which, for the most part, is waterworn, with occasional talus slopes of angular rock. The second zone, which includes all the land above 300 feet, is covered deeply with large angular blocks, has its bedrock exposed in a few places only, and all glacial form mostly destroyed. The contact between these two areas is marked in places by pebble and boulder patches along the hillsides in some of the valleys.

*Palæontological evidence of elevation.*—In one of the valleys, 270 feet above sea level, was found a large deposit of well-preserved shells, representing two genera living at present, *Mucoma calcarea*, Chemnitz,<sup>1</sup> and *Mya truncata*, Linn. (?). These were not found in direct association with the beaches, but were only a short distance from one series, and were taken from a small area of black mud, not covered by vegetation.

Dawson refers to several cases in southern and eastern Can-

<sup>1</sup> The writer is indebted to MR. E. M. KINDLE for the identification of species.

ada where vertebrate remains, especially the whale, are associated with raised beaches. In speaking of the lower St. Lawrence in the neighborhood of Little Meta,<sup>1</sup> he says, "Bones of large whales occasionally occur on this terrace." After describing a beach on the island of Anticosti,<sup>2</sup> he says, "The bones of a whale were found on this beach." He further states that the same condition is observed along the shore of the St. Lawrence<sup>3</sup> and at Smith's Falls,<sup>4</sup> Ontario. The beach at the latter place has an elevation of 420 feet above the level of the sea.

Packard<sup>5</sup> refers to the same association on the lower Savage Islands. In each case invertebrate shells representing several genera and species were found occurring with the vertebrate remains, but in greater abundance, as would be expected.

*Southern coast of Baffin Land, about twenty miles north of Ashe Inlet.*<sup>6</sup>—Three stops were made on the mainland at different places, and at each one proofs of recent elevation were seen in the form of raised beaches. At the first landing, which was across White Strait to the north, and opposite the middle, of Big Island, about twenty miles from Ashe Inlet, the beaches were associated with other forms of evidence, above mentioned, as being present on the island; viz., fossils and difference in degree of weathering above certain heights. The rock of this part of Baffin Land is a fine-grained, garnetiferous gneiss, and thus differs from the rock of the island. The land is low near the coast, but rises into a series of hills which at a distance of a mile or more back from the sea reach an elevation of 700 feet, continuing to rise inland.

*Raised beaches.*—These did not attain so perfect a degree of development as those on the island. They were formed in very narrow valleys, crescentic in shape and concave seaward, damming back small ponds or lakelets. In one place, where this condition

<sup>1</sup> The Canadian Ice Age, 1894, p. 65.

<sup>3</sup> *Ibid.*, p. 161.

<sup>2</sup> *Ibid.*, p. 159.

<sup>4</sup> *Ibid.*, p. 203.

<sup>5</sup> Memoirs Bost. Soc. Nat. Hist., 1867, I, Part II, p. 226.

<sup>6</sup> The writer was landed on Big Island and did not visit this part of the mainland. For what follows he is indebted to PROFESSOR R. S. TARR, who has very kindly furnished him with all the facts.

was especially noticed, it looked in every way as though it were artificial; the crescentic beach, which held up a lake behind it, had been so regularly constructed that had it been in an inhabited region Professor Tarr states that he should have ascribed it to the hand of human beings instead of to nature's handiwork. These crescentic lines were composed of large boulders, weighing from fifteen to twenty pounds, and in length were from 100 to 125 feet, rather narrow topped, probably six feet across, but several times this width at base. The exact counterpart of these was seen in process of formation in one place at sea level, in which the ice was an important factor in their construction. The ice, moving in strong tidal currents, bore along boulders and ground them against the coast, forming a boulder pavement of a very perfect kind.<sup>1</sup> Professor Tarr states that, due to the narrowness of the valleys, it would be impossible for these to form without the aid and action of the ice, for no waves could exist here which would transport and pile up such an accumulation of boulders, particularly when below the zone of ice action the bottom is clayey.

*Fossils.*—The following genera of living shells were found: *Mya*, *Saxicava*, *Pecten*, *Terabratula*, *Balanus*, and several other living species. These were found in a blue mud, some patches of which were fifty to sixty feet across, in some cases covered with moss, and in others not. Fossils were also found at lower levels.

*Weathering.*<sup>2</sup>—Professor Gill independently suggested recent elevation purely on the basis of the weathering of the rock in place. In chipping and breaking off petrographical specimens he found a striking difference in degree and intensity of weathering, which he placed at an elevation of from 300 to 400 feet. The rocks below this elevation were found to be much less

<sup>1</sup> For action of similar kind described by PACKARD and FEILDEN along the Labrador coast see references in Bibliography.

<sup>2</sup> I am indebted to PROFESSOR A. C. GILL for kindly furnishing me with this fact. The exact elevation of contact marking the difference in degree of weathering was not determined.

affected or changed by the weathering agencies than those above this height.

*Icy Cove, southern part of Meta Incognita.*—Our second landing place was on the southwest coast of a peninsula lying between Frobisher Bay and Hudson Strait, and about sixty miles east of Big Island. This land is known as Meta Incognita, and the landing was at "Icy Cove," where the only Eskimo settlement in the Straits was found, called "Noogla."

The topography here was much the same as that of the other two places—very rugged—and like Big Island the coast was steep and rough, indented with embayments and rocky capes or headlands. The rock is a very coarse-grained granitic gneiss.

*Raised beaches.*—Two beaches were noted, composed of coarse, rounded material. No elevations were taken, but these looked to be about 50 and 100 feet, respectively, above sea level. A bench between the two beaches was seen, which appeared to be a wave-cut terrace, at an elevation of about 75 feet.

*Niantilik Harbor, Cumberland Sound.*—This was our last landing on the Baffin Land side. Niantilik Harbor is a fiord on the south side of Cumberland Sound. A stream of considerable size enters at this point, having its head waters in a series of true rock-basin lakes of rather large size.

*Raised beaches.*—It is along the west side of this valley that we have a series of unusually large and well-developed beaches. Unlike those described from the other localities, these are composed of fine material, excepting the topmost one, which consists of coarse shingle. The direction of the two principal beaches is approximately parallel to the stream, N.  $75^{\circ} 55'$  W. The first one is at an elevation of 110 feet above low tide, 200 yards long, with an average width of 30 yards, and is composed of sand, gravel and pebbles.

The second beach is from 50–100 feet above the first one, fully three-quarters of a mile long and with an average width of 75 feet, and is built of very large boulders. It is not so well preserved as the lower one, as it lies against a very high and steep scarp, with its flat-topped condition seen in only a few

places, and for rather short distances, the rest being almost entirely masked by the piling up of the products of weathering. An intermediate stage is represented by a beach some 50 yards long and as many wide, composed of very fine material, mostly sand and gravel, and acting as the divide in the very shallow valley in which it is built. The two large beaches grade or run into rock-basin lakes at their eastern ends.

The cemetery of Black Lead Island is built on a well-defined beach composed of sand and gravel, and is at an estimated elevation of between 100 and 125 feet above sea level. Beaches were noticed at several other places, but time would not admit of their study.

A condition, unlike that seen at any of the other places, was noticed on all of the lands enclosing this harbor, which, in itself, would have a tendency to indicate or suggest elevation. The condition was that of a form of rocky headland or cape of peculiar development, cut out of the solid rock, primarily, by wave-cutting and perhaps, subsequently, by ice erosion to an unknown extent. They were very numerous, extended seaward for quite a long distance, were very narrow—only a few yards at widest—and were of a remarkably level-topped condition, rising five to ten and twenty feet above sea level. At about the same level notches of wave-cut origin were more or less distinctly noticeable, and while time would not admit of their study, they apparently were in correlation with the capes. Partial evidence was found which seemed to indicate recent elevation of some 50–100 feet above the highest beach mentioned.

*Evidence of present rising of the land on Big Island around Ashe Inlet region and at Niantilik Harbor.*—At each of these places, in nearly every valley studied, was found a beach built of fine material, sand and gravel, at an elevation of from five to ten feet above high tide. The evidence of present upward movement at Niantilik is made stronger by the peculiar type of rocky headland, extending seaward.

Bell<sup>1</sup> has shown evidence of a like kind indicating a similar

<sup>1</sup> Canad. Geol. Survey, Rept. of Prog. 1882, 1883, 1884, pp. 26, 31, 33 and 35, DD.

uplift of the lands to the west of the region herein described, and with Tyrrell<sup>1</sup> has proven the raised or elevated condition along the west and southwest shore of Hudson Bay. Again, Bell<sup>2</sup> has produced sufficient evidence, although doubted by Tyrrell,<sup>3</sup> that the Hudson Bay region has been elevated in historic times; the elevation being believed to be in progress at present.

No landing was made on the lands along the south side of the straits, but during the summer of 1884 Dr. Robt. Bell of the Canadian Geological Survey was sent out as the geologist by the Canadian government, through the straits and into Hudson Bay, and he has described raised beaches on some of the islands to the west and southwest of Baffin Land. For convenience I quote from Dr. Bell's report:

Speaking of Cape Prince of Wales,<sup>4</sup> he says: "Beaches of shingle, as fresh looking as those on the present seashore, except that the stones are covered with lichens, may be seen at all levels, up to the tops of the highest hills in this vicinity. . . . The materials of the raised beaches above referred to consist principally of gneiss with milk quartz from the veins of the neighborhood, together with a few fragments of yellowish gray dolomite, with obscure fossils, a hard and nearly black variety of siliceous clay slate, with an occasional boulder of dark, hard crystalline diorite."

Concerning Digges Island,<sup>5</sup> he says: "Between this and the western extremity of the island the hills have a rounded outline, and raised beaches, composed mostly of coarse shingle, form a prominent feature on their slopes, all the way from high tide mark to their summits, the highest of which is between 300 and 400 feet."

Mansfield Island,<sup>6</sup> he says: "For many miles, the whole of the eastern slope of the island presents a succession of steps or

<sup>1</sup> Geological Magazine, Decade 4, Vol. I, 1894, p. 398.

<sup>2</sup> Am. Jour. Sci., Vol. I, Fourth Series, 1896, pp. 219-228.

<sup>3</sup> *Ibid.*, Vol. II, Fourth Series, 1896, pp. 200-205. For other references to this region see Bibliography.

<sup>4</sup> Canad. Geol. Sur. Rept. Prog. 1882, 1883, 1884, p. 26, DD.

<sup>5</sup> *Ibid.*, p. 31, DD.

<sup>6</sup> *Ibid.*, p. 33, DD.

small terraces, mostly too low to be distinctly counted, but there might be a hundred of these between the sea level and the highest parts of the island visible. These appeared to be partly ancient beaches, and partly the outcropping edges of nearly horizontal strata."

Marble Island,<sup>1</sup> he says: "Even the boulders and coarse shingle forming the raised beaches remain quite white, and these beaches appear as conspicuous horizontal lines against the dark vegetable matter."

*Degree of rapidity of the uplift.*—It is strikingly noticeable from the description of the beaches given above, as also from their study in the field at the various localities in which they occur, that the conditions suggest a difference in the rapidity of movement with which the land was raised above the waters at the successive stages and levels. The movement seems to have varied in intensity or rate for the same locality. In the case of the two highest beaches on Big Island and at Niantilik harbor, the conditions point very strongly indeed to a uniformly slow change in level. The interval between the two beaches at each of these places is marked by intermediate fragmentary lines. Materials are strewn thickly over the area between in an interlocking manner. This condition is strikingly absent from the land areas between the lower beaches. Thus the change in level from the second highest beach downward was sudden and rapid, and is better described as having taken place by *jumps*, so to speak; while above this line the change in level must have been less sudden and violent, and in character slow and gradual. At Icy Cove and the mainland to the north of Ashe Inlet, the conditions indicate the same sudden or rapid *jumping* movement as in the lower levels at Niantilik and Ashe Inlet.

Going still farther westward the lands along the west coast of Hudson Bay have been described as containing raised beaches, thus indicating recent elevation in that region. In speaking of the raised beaches in the Aberdeen Lake region, Mr. Tyrrell<sup>2</sup>

<sup>1</sup> Canad. Geol. Sur. Rept. Prog. 1882, 1883, 1884, p. 35 DD.

<sup>2</sup> Geol. Mag., 1894, Vol. I, decade 4, p. 398.

says that they are found at the following elevations above the lake, 290, 220, 180, 150, 105, 90 and 60 feet; also, "Similar raised beaches are found in favorable localities all along the shore of Hudson Bay." In Mr. Tyrrell's<sup>1</sup> account of his first expedition through the barren lands of northern Canada, he mentions raised beaches in two localities, one at Doobaunt Lake with an elevation of some 400 feet above sea level; the second at the mouth of Chesterfield Inlet and on the south side. In Tyrrell's<sup>2</sup> second trip through these regions raised beaches are mentioned near Ferguson Lake at an elevation of from 400 to 500 feet above sea level, and on the southwest side of Churchill River in the region of Deer River with an elevation of some 600 feet.

*Conclusions.*—1. The evidence favoring recent elevation of from certainly 270 to 300 feet above present sea level on the lands along the south and southeast coast of Baffin Land has been shown to be of the most conclusive character, and can be briefly summed up under three general headings.

*a.* In the form of raised beaches.

*b.* Unlike surface conditions intimately associated with a difference in degree of weathering at a well-defined elevation.

*c.* In the form of extinct life. The remains of several genera and species of living shells were found to be in greater or less degree directly associated with the beaches.

Furthermore, that the conditions attending this upward movement at least show that the rate of movement was not alike for all the localities studied, but rather indicates that for some the uplift was sudden and rapid, rising by jumps or strides, while for others it was more uniformly slow and gradual.

2. Conditions strongly favor a present movement on Big Island and in Cumberland Sound. This is shown in beaches found in a great number of the fiordic valleys, which are at present out of the reach of high tide by some five to ten feet, but so recently formed that not a sign of vegetation has commenced

<sup>1</sup> Geog. Jour. (London), 1894, July-Dec., Vol. IV, pp. 444-447.

<sup>2</sup> *Ibid.*, 1895, July-Dec., Vol. VI, pp. 445-447.



to grow on the beach materials. Also, by the peculiar type of rocky headland and wave-cut notches above described, and at about the same elevation as the lowest beaches.

3. It would further appear that the uplift along south Baffin Land was coextensive with that described by Bell and Tyrrell in the Hudson Bay region.

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ITHACA, N. Y.,

December 10, 1896.

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